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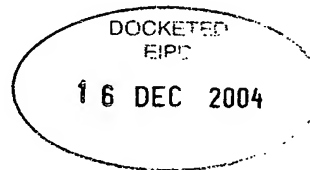
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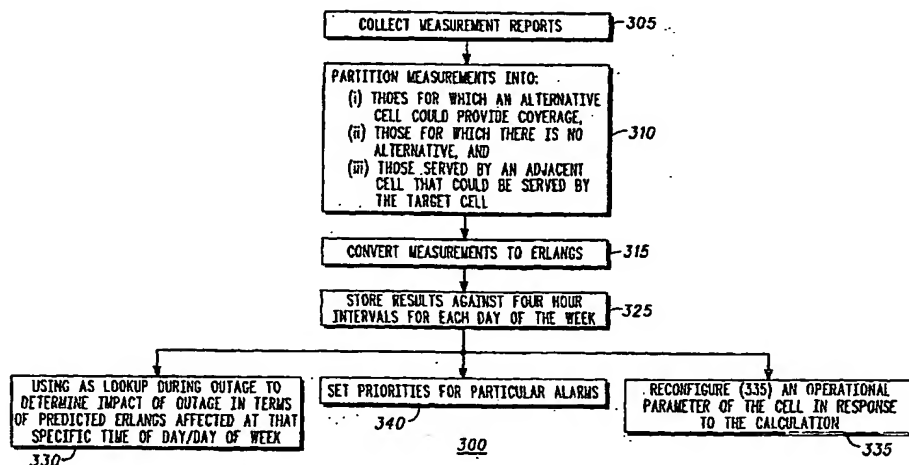
(57) Abstract: A method (300) determines a per-cell coverage area in a cellular communication system that comprises multiple cells. The method comprises measuring (305) one or more parameters relating to one or more operations of a first cell in a cellular communication system. The method includes calculating (320) a degree of coverage overlap from a number of measurements, preferably by comparing a number of first measurements relating to a location that is uniquely served, with a number of second measurements that can be served by a plurality of serving communication units. Tn this manner, it is possible to determine an amount of overlapping coverage area based on real network measurements rather than inaccurate predicted data that has been t--aditionally employed. Preferably, the measurements afe converted to Erlangs to provide a coverage overlap based on subscriber traffic. A communication system (100) and a communication unit (146) are also provided.

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METHOD FOR DETERMINING A COVERAGE AREA IN A CELL-BASED COMMUNICATION SYSTEM

Field of the Invention

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This invention relates to determining the coverage of a
cell in a cell-based communication system. The invention
is applicable to, but not limited to, utilising such
coverage information to assist alarm prioritisation due
10   to cell outage and/or re-configure a system's or cell's
operational parameters to minimise the degree of
overlapping coverage, thereby allowing higher
capacity/quality frequency plans to be deployed.

15   Background of the Invention

Wireless communication systems, for example cellular
telephony or private mobile radio communication systems,
typically provide for radio telecommunication links to be
20   arranged between a plurality of base transceiver stations
(BTSs) and a plurality of subscriber units, often termed
mobile stations (MSs).

In a wireless communication system, each BTS has
25   associated with it a particular geographical coverage
area (or cell). Primarily, a particular transmitter
power level defines a coverage area where a BTS can
maintain acceptable communications with MSs operating
within its serving cell. In addition, receiver
30   sensitivity performance of receiving wireless
communication units also affects a given coverage area.
In large cellular communication systems, these cells are
combined and often overlapped to produce an extensive
coverage area.

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Wireless communication systems are distinguished over
fixed communication systems, such as the public switched
telephone network (PSTN), principally in that mobile
5   stations move between coverage areas served by different
BTS (and/or different service providers) and, in doing
so, encounter varying radio propagation environments.

In a cellular system, adjacent cells are typically
10   configured to overlap, to ensure a contiguous signal
coverage area. The cell overlap region is deliberately
designed into the system plan to ensure that mobile
stations can successfully handover between cells. The
degree of coverage overlap between cells can vary
15   enormously. In such systems it is desirable to have an
accurate measure of unique cell coverage (and ideally
cell overlap) to operate and maintain the network more
effectively (i.e. maximising capacity and quality of
service).
20

A system design based on cells is typically based on an
ideal cell pattern. However, an idealised cell pattern
never occurs in practice, due to the nature of the
terrain and the fact that cell sites and antennae are not
25   ideally located on a regular grid pattern. The network
designer therefore uses frequency planning tools to
estimate the radio propagation for each cell and predict
a corresponding coverage area. Based on these
propagation models, the network designer is able to
30   develop a frequency plan for the network intended to
minimise the expected interference. The frequency plan
considers such factors as antenna heights and location,
terrain topology, transmitted power levels and the
anticipated number of subscribers.

By collating predicted coverage area information for a
number of cells, it is possible to determine a degree of
coverage overlap between a number of respective cells.

5   However, the accuracy of these tools is limited, since
they 'predict' the theoretical coverage rather than
measure the actual coverage supported by a particular
BTS.

10   The quality of a frequency plan that can be produced by
such coverage prediction techniques is constrained by the
degree of coverage overlap between cells. Greater
overlap means greater potential interference, making it
more difficult to produce a low interference frequency

15   plan. A traditional method of allocating frequencies in
a wireless cellular system is to employ a channel
allocation algorithm in conjunction with a carrier-to-
interference (C/I) matrix, where the C/I matrix may use
measurement report data.

20

Achieving an optimum frequency plan is therefore
dependent on the C/I matrix accuracy, and it is
inaccuracies in these matrices that ultimately lead to
unexpected interference. There are a number of reasons

25   why traditionally produced matrices are inaccurate. For
example, the matrices are based on predicted interference
levels at ground level, i.e. subscribers in high
buildings are not considered. They assume fixed cell
boundaries whereas the characteristics of MSs and

30   handover algorithms are such that cell boundaries can
move. Also, they are reliant on accurate site and
antenna data. This data can be far from accurate with
some Operators having no clear idea of where their sites
are, let alone being confident in the bore angles of the

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antennas. They do not reflect the impact of detailed clutter data, such as street canyons.

Furthermore, these coverage prediction techniques tend to
5 focus on geographic coverage area, assuming an even distribution of MSs within the cell, rather than subscriber-based coverage where subscribers are unevenly distributed across a cell. This inaccuracy limits the effectiveness of the predictions and the resulting
10 decisions made therefrom. This, in turn, means that the network is sub-optimally configured and therefore typically delivers a sub-optimal quality of service.

The inventors of the present invention have therefore
15 both recognised and appreciated that there is currently no accurate method of determining an accurate cell-based coverage map, particularly when there exists coverage overlap between cells.

20 In the context of network optimisation, it is known that measurement reports are collected from an operational network, as described in co-pending UK Patent Application GB 9926513.4 having the same Applicant as the present invention. The data collected is then analysed to
25 generate neighbour cell list for handover purposes and facilitate power control decisions. In this regard, it is known that MSs scan signal transmissions from multiple BTSs and report the signal levels of these in the measurement reports. The scanning process, which is used
30 to generate the measurement reports, enables the MS (or its serving BTS) to determine optimal handover candidates, namely the BTS offering the highest quality signal/communication link to the respective MS.

5

Thus, there exists a need in the field of the present invention to provide a cell-based communication system and method for determining coverage overlap in a cell-based communication system, wherein the aforementioned

5 disadvantages may be alleviated.

Statement of Invention

In accordance with a first aspect of the present

10 invention there is provided a method of determining coverage in a cellular communication system, as claimed in Claim 1.

In accordance with a second aspect of the present

15 invention, there is provided a storage medium, as claimed in Claim 10.

In accordance with a third aspect of the present invention, there is provided a communication system, as

20 claimed in Claim 11.

In accordance with a fourth aspect of the present invention, there is provided a communication unit, as claimed in Claim 12.

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In summary, the inventive concepts of the present
invention propose a mechanism for using measurement
reports (MRs) to determine the unique coverage and the
potential interfering (overlapping) coverage generated by

5   each cell, preferably determined in terms of Erlangs. By
utilising MRs in this manner, the Network Operator is
able to direct and prioritise both automatic and manual
maintenance and optimisation activities, for example,
alarm prioritisation to distinguish the more critical

10   coverage cells. Alternatively, or in addition, the
coverage calculations, according to the preferred
embodiment of the present invention, may be used to re-
configure a system's operational parameters, such as:
transmit power, a beam-forming antenna tilt or direction,

15   and even turning off cell sites whose excessive coverage
overlap provides unacceptable interference or severely
restricts the frequency allocation process.

Brief Description of the Drawings

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Exemplary embodiments of the present invention will now
be described, with reference to the accompanying
drawings, in which:

25   FIG. 1 illustrates a block diagram of a cellular radio
communications system adapted to support the various
inventive concepts of a preferred embodiment of the
present invention;

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FIG. 2 illustrates a cell-based communication system
adapted to support the various inventive concepts of a
preferred embodiment of the present invention; and

5   FIG. 3 illustrates a flowchart of a method of determining
an overlapping coverage area, and thereafter utilising
such information, in accordance with a preferred
embodiment of the present invention.

10   Description of Preferred Embodiments

The inventive concepts of the present invention propose a
mechanism for using measurement reports (MRs) to
determine both the unique and overlapping (and therefore
15   interfering) coverage generated by each cell.   In
particular, three aspects of a respective cell's coverage
may be determined:
           (i) The amount of traffic that receives coverage
uniquely from this cell;
20   (ii) The amount of traffic that receives coverage
from this cell, but which could also obtain coverage from
an adjacent cell; and
           (iii) The amount of traffic carried by adjacent
cells that could provide coverage to this cell.
25

From a perspective of a serving cell, at one extreme, it
is known that the coverage area of the cell may be
completely overlapped by one or more adjacent cells.   At
the other extreme, the coverage area of two cells may be
30   configured to not overlap at all.   This variation has
significant implications for system operation.   For
example, if a cell goes off-air, then subscriber units in
the area uniquely covered by this cell will no longer
have service.   However, if there is a large degree of

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overlap from neighbouring cells, then many subscriber
units will be able to receive service from neighbouring,
but less-preferred, cells. Conversely, with no overlap,
all subscriber units will lose service.

5

Hence, in accordance with a preferred embodiment of the
present invention, a mechanism to determine an accurate
knowledge of coverage overlap is proposed. Once an
accurate knowledge of coverage overlap has been

10   determined the relative importance of keeping various
cells on air can be identified.

The inventors of the present invention have appreciated
that those cells providing the most unique coverage are

15   the most critical to be maintained. Therefore, for
example in a first embodiment of the present invention,
the resulting cell outage alarm should be set to reflect
the uniqueness and importance of the cell. Furthermore,
in a second embodiment of the present invention, such

20   knowledge also helps determine network availability as
well as enabling a Network Operator to set optimum system
parameters. Furthermore, such knowledge enables higher
capacity and better quality frequency plans to be
deployed.

25

From a perspective of a neighbouring, overlapping cell,
at one extreme, the cell may overlap with many
neighbouring cells. Alternatively, the cell may overlap
with no other cells. This variation impacts frequency

30   planning, since the frequencies assigned to a cell with
large overlap cannot be re-used in the overlapped cells,
making frequency planning more difficult. However, a
cell with a large overlap may be useful for providing

continuity of service, should the overlapped cells go out
of service or become congested.

The inventive concepts of the present invention alleviate
5   the aforementioned problems associated with the coverage
prediction by extending the concept of an Intelligent
Optimisation Service (IOS), as described later. In
particular, the present invention proposes a mechanism of
using existing measurement reports to assist in
10   determining a level of coverage overlap. Furthermore,
once such measurement reports have been received and
processed and coverage overlap information has been
calculated, the information can be used in a variety of
ways, as detailed later.
15

Referring first to FIG. 1, a cellular telephone
communication system 100 is shown, in outline, supporting
a Global System for Mobile communication (GSM) air-
interface, in accordance with a preferred embodiment of
20   the invention. The European Telecommunications Standards
Institute (ETSI) has defined the GSM air-interface.

Generally, the air-interface protocol is administered
from base transceiver sites, within the network
25   architecture 110, that are geographically spaced apart –
one base site supporting a cell (or, for example, sectors
of a cell), as shown in FIG. 2.

A plurality of subscriber units 112-116 communicate over
30   the selected air-interface 118-120 with a plurality of
base transceiver stations (BTS) 122-132. A limited
number of MSs 112-116 and BTSs 122-132 are shown for
clarity purposes only. The BTSs 122-132 may be connected
to a conventional public-switched telephone network

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(PSTN) 134 through base site controllers (BSCs) 136-140 and mobile switching centres (MSCs) 142-144.

5 Each BTS 122-132 is principally designed to serve its primary cell, with each BTS 122-132 containing one or more transceiver units and communicating 156-166 with the rest of the cellular system infrastructure

Each BSC 136-140 may control one or more BTSs 122-132, 10 with BSCs 136-140 generally interconnected through MSCs 142-144. Processes within the MSCs are provided to account for the situation where a MS (112-116) passes between two BTS serving areas, for example MS 112 moving from an area covered by BTS 122 to an area covered by BTS 15 124, where the two BTSs are controlled by different BSCs (BSC 136 and BSC 138 in this example).

Similar processes are supported in MSCs to account for the situation where an MS moves between serving BTSs 20 where these BTSs are connected to different MSCs. These mechanisms therefore allow the cellular telephone communication system to support handover of MSs 112-116 between overlapping cells in a contiguous, seamless manner.

25

Each MSC 142-144 provides a gateway to the PSTN 134, with MSCs 142-144 interconnected through an operations and management centre (OMC) 146 that administers general control of the cellular telephone communication system 30 100, as will be understood by those skilled in the art.

The various system elements, such as BSCs 136-138 and OMC 146, include control logic 148, 150, 152, with the various system elements usually having an associated

memory function 157 (shown only in relation to OMC 146 for the sake of clarity). A memory function 157 of the OMC 146 typically stores historically compiled operational data as well as in-call data, system
5   information such as neighbouring cell-site lists and control algorithms such as a list of frequencies to be scanned by the respective MSs.

In accordance with the preferred embodiment of the
10 present invention, the OMC or an optimisation function adjunct to the OMC 146 receives Measurement Reports (MR) collected from respective cells, either from, say, serving BTSs and/or served MSs. In the context of the present invention, it is envisaged that an OMC's handling
15 of MRs may be complemented or replaced by any such adjunct optimisation function. As such, the following description of the OMC's functionality in this regard encompasses any such suitable configuration. Notably, the OMC 146 has been adapted to include an overlapping
20 coverage calculation function 155. The overlapping coverage calculation function 155 utilises the MR data to determine those cells that provide a unique coverage to MSs within those cells. The overlapping coverage calculation function 155 also utilises the MR data to
25 determine those cells where some coverage can be supported by neighbouring cells.

In this regard, the OMC is able to calculate an amount of overlapping coverage. The OMC 146 has been
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configured to receive any operational/ environmental data
provided by the system elements or UEs relating to the
operational characteristics of the respective cells, in
order to determine, for example, a level of unique
5 coverage that respective cells provide.

In a further enhanced embodiment of the present
invention, one or more BSCs 136 and/or one or more BTSs
122 may include, or be operably coupled to, an MR agent
10 (not shown). The BSC 136 or BTS 122 preferably
configures the agent to seek out and record measurements
for the requisite environmental or operational data that
may affect the overlapping coverage area of the cell.

15 It is also envisaged that the cell's MR information may
be sent from any number of sources and include any useful
data. In particular, the information may include:
       (i) Cell statistical information, available at
the OMC, such as Congestion, Blocking, Mean-Hold Time
20 (MHT), Handover (HO) Cause distribution;
       (ii) Measurement Reports, which indicate the
Radio Frequency (RF) environment of the subscriber units;
or
       (iii) Control Signalling behaviour. This
25 information is readily available to the OMC function in
existing systems. It forms the basis of reports
generated for the Network Operator to analyse during the
course of normal operational activities.

30 In particular, if a MR from a MS contains no neighbouring
BTS measurements, or only very weak neighbour
measurements, it can be assumed that the MS could not
achieve service from any neighbouring cell. This

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information is particularly useful to the OMC 146, should
that serving cell go off-air or become congested.

Conversely, if the MR contains one or more neighbour
5   measurements indicating a strong received signal, then it
can be assumed that the MS could obtain service from one
of these neighbours, if its serving cell becomes
unavailable. Thus, by analysing all the MRs collected
from a particular cell, it is possible to determine, for
10   example, a proportion of the cell's traffic that depends
solely on that cell for service. In this context, the
OMC 146 is able to determine an unique coverage factor
for that cell (UCF), where:

15              $$UCF = \frac{\text{Sum of MRs with no/weak neighbours}}{\text{Total Sum of MRs}} \quad [1]$$

In the context of the present invention, a weak neighbour
is defined, for example, as a neighbour reported with a
20   received signal level (RXLEV) of < 'X', where 'X' can be
set by the Network Operator, for example, set at an RXLEV
of '10' (equivalent to, say, -100dBm).

In the enhanced embodiment of the present invention, the
25   OMC 146 comprises an overlapping coverage calculation
function 155 to generate/calculate a subscriber-based
coverage map that particularly indicates coverage
overlap.

30   Preferably, the calculation to determine the degree of
overlapping coverage is based on the number of times that
a cell is reported as a neighbouring cell, by subscriber
units in the other network cells. Indeed, in accordance
with the preferred embodiment of the present invention,

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this information can easily be extracted from existing
measurement report information. In this regard, a
carrier-to-interference (C/I) matrix of rows and columns
is produced, where each column represents the potential
5   interference generated by a specific cell.

A simplified example of such a matrix is illustrated
below in Table 1. The rows represent the cells 'A'-'D'
as serving cells, and the columns represent cells 'A'-'D'
10   as interfering cells. For example, cell 'B' can expect
to lose six Erlangs of traffic due to interference, if it
has the same frequency as cell 'C'. Hence, the amount of
coverage overlap generated by each cell, which could
potentially lead to interference, is represented by the
15   total of the column for the respective cell. Thus, in
this example, Cell 'B' has the highest overlap with forty
Erlangs of traffic seen in other cells at a strong level.

Table 1:

	A	B	C	D
A		10	5	10
B	12		6	10
C	5	15		17
D	7	15	5	
Total	24	40	16	37

20

Advantageously, the use of Measurement Reports ensures
that 'real' measurement data from the actual operating
network is used, in contrast to the known technique of
25   using inaccurate prediction data. By ensuring that a
statistically significant volume of Measurement Reports
are used in the calculations, it is possible to guarantee
that the resulting measures or calculations of unique
cell coverage and cell overlap are extremely accurate.
30   These values represent the cell coverage and overlap from

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the perspective of all the network subscriber units.
Consequently, the impact on the network subscriber units,
of decisions made using this data, can be accurately
determined.

5

In accordance with the preferred embodiment of the
present invention, the memory element 157 of the OMC 146
has also been adapted to include, for example, a look-up
table of the coverage overlap information. In this
10 regard, the look up table contains information relating
to one or more of the following:

> (i) Cell operational parameters,

> (ii) Threshold values used in the respective
cell(s),

15 > (iii) Traffic profile information for that cell,

> (iv) Received signal level information, say from
a number of MSs, for that cell – irrespective of whether
the MSs are being currently served in that cell, or

> (v) Transmitter power information, for either BTS
20 and/or MS, relating to a particular cell.

Although the inventive concepts of the present invention
have been described with regard to an implementation in
an OMC 146, it is within the contemplation of the
25 invention that the overlapping coverage calculation
function 155 may be provided in a separate device or
function, operably coupled to the OMC 146.
Alternatively, the overlapping coverage calculation
function 155 may be located within any other element
30 within the infrastructure, such as MSCs 142, 144, or
within BSCs 136, 138, 140 or even

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distributed within a number of elements, if appropriate.
For example, the overlapping coverage calculation
function 155 could be implemented within the radio access
network (RAN) of the cellular infrastructure equipment
5   and/or it may be implemented as a stand-alone
element/function on an adjunct platform. Indeed, it is
envisaged that the OMC as a logical entity could comprise
several distributed or substantially co-located boxes
with specific functions, including an optimisation (IOS)
10 box.

In a preferred embodiment of the present invention, it is
also envisaged that one or more BTSs 122-132 and/or one
or more BSCs 136-140 may be adapted to regularly or
15 intermittently collect the MR data. This information
would then be forwarded to the OMC 146 (or indeed any
other associated element) where the overlapping coverage
area mapping/calculation function 155 resides.

20 More generally, an overlapping coverage calculation
function 155 may be programmed into, say, the OMC 146
according to the preferred embodiment of the present
invention, in any suitable manner. For example, new
apparatus may be added to a conventional communication
25 unit (for example OMC 146). Alternatively existing parts
of a conventional communication unit may be adapted, for
example, by reprogramming one or more processors therein.
As such the required adaptation may be implemented in the
form of processor-implementable instructions stored on a
30 storage medium, such as a floppy disk, hard disk,
programmable read only memory (PROM), random access
memory (RAM) or any combination of these or other storage
media.

17

Referring now to FIG. 2, a cell-based communication
system 200, adapted to support the various inventive
concepts of a preferred embodiment of the present
invention, is illustrated. FIG. 2 is a representation
5 of, say, a street level coverage map from Cells A 210, B
220, C 230, D 240, E 250, F 260 and X 270. As with a
vast majority of cell-based wireless communication
systems, there is significant degree of overlap between
cell coverage areas. A key illustration in FIG. 2 is
10 that although the coverage area of Cell X 270 is
significant, most of its coverage could be supplemented
by coverage from neighbouring cells 'A' to 'F' 210-260.
The proportion of unique coverage that is solely
supportable by cell X 270 is an island of coverage at the
15 centre of cell X 270. Any subscriber units located in
this region would definitely suffer a complete outage if
Cell X 270 were to go out of service.

Although FIG. 2 illustrates the geographical coverage
20 impact of such an outage, a key benefit of the present
invention is to determine a number of Erlangs of traffic
that would be lost due to the outage. For example, let
us assume that only 10% of the cell's coverage area is
uniquely served by this cell.
25

However, if all the subscriber units in the cell are
concentrated in this one small central area, then the
impact of a cell outage will be to remove service from
100% of the cell's traffic, not just 10% that relates to
30 the geographical impact. Thus, it is the Erlang value
related to impacted traffic that is preferably used in,
for example:

          (i) Prioritising a resulting outage alarm, and/or

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(ii) Re-configuring a system's operational
parameters.

In an enhanced embodiment of the present invention, the
5   potential interference generated by cell X 270 on
neighbouring cells 'A'-'F' 210-260, based on a level of
overlap between the cells, may be used to determine
whether to re-configure cell X's operational parameters.
For example, the transmit power of cell X 270 may be
10   reduced, or antenna down-tilting of Cell X's beam-forming
antenna introduced.

Referring now to FIG. 3, a flowchart 300 illustrates an
overview of the preferred overlapping coverage
15   measurement process. The flowchart commences with an OMC
(or other box) collecting a series of Measurement Reports
(MRs), for example.resulting from a subscriber unit
polling operation, as shown in step 305. MRs are
collected from the target cell and from its neighbouring
20   cells.

These MRs are then separated into, say, three categories,
in step 310:
(i) Those MRs for which an alternative cell is
25   identified as being able to provide coverage;
(ii) Those MRs for which there is no alternative
coverage option, i.e. the subscriber unit generating the
MR can only be served by that cell in that location; and
(iii) Those MRs collected from neighbouring cells
30   that show a strong level of coverage from the target
cell.

The OMC then converts the MR information into Erlangs, in
step 315, to determine the traffic impact, rather than

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the geographical impact, of any potential cell outage.
These results may then be stored, in step 325, according
to the time of day, day of the week, month and any
additional cell parameter information such as transmit

5   power, and subscriber unit information such as cell
location (say, from a GPS unit). In the illustrative
step 325, the results are stored against four-hour
intervals for each day of the week: however clearly the
results may be stored using any storage/sorting method

10 determined by a skilled person.

Thus, in this manner, an OMC determines how much traffic
coverage is uniquely provided by a particular cell, for
example, using existing measurement report data.

15 Preferably, a statistically valid sample of MRs is used
in the determination of overlapping and/or unique
coverage. Once an Erlang figure has been determined,
this figure is used to influence the Network Operator (or
the OMC) to improve the network's performance.

20

For example, the figure is used to determine an
appropriate cell outage strategy, in step 330. It is
envisaged that such a use may entail determining when and
how to maintain a cell, i.e. by turning the cell off.

25 The traffic impact of such cell maintenance can therefore
be minimised. Furthermore, the cell outage strategy may
encompass the OMC using the Erlang value of uniquely
covered traffic to select an alarm priority setting for
the cell, as shown in step 340.

30

Advantageously, the unique coverage capability and
coverage overlap information of the cell can also be used
to automatically re-configure operational parameters in a
cell, as shown in step 335. Such a re-configuration of

20

operational parameters helps determine and implement a
feasibility of beam-forming changes such as down-tilts,
provision of additional redundancy, etc.

5   The inventive concepts of the present invention utilise
dynamic monitoring and adaptation of a cell's operational
parameters. Such information, when obtained extensively
throughout the system, may be assessed to better plan and
utilise available communication resources (frequencies)
10   throughout the system. In this manner, it is envisaged
that an automatic frequency planning operation may
benefit from the inventive concepts described herein.

It is within the contemplation of the invention that the
15   OMC 146 may use any additional indicia, such as traffic
load, time of day, etc. to enhance the assessment of
communications within the communication system. It is
also envisaged that the OMC 146 (or other element) may
poll BTSs or MSs within the system to obtain such
20   additional indicia. Further variations that fall within
the inventive concepts herein described will be apparent
to a person skilled in the art.

The preferred embodiment of the present invention has
25   been described with regard to a cellular telephony
communication system, such as the global system for
mobile communications (GSM). It is envisaged that the
invention is equally applicable to other wireless
communication systems, such as a universal mobile
30   telecommunication system (UMTS), any code division
multiple access (CDMA) or time division multiple access
(TDMA) system, or an integrated digitally enhanced
network (iDEN)™ as supplied by Motorola™. It is also
within the contemplation of the invention that

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alternative radio communication architectures, such as private or public mobile radio communication systems could benefit from the inventive concepts described herein.

5

It will be understood that the communication system, communication unit, and improved method for coverage prediction, as described above, provides at least some of the following advantages that could not be reliably

10   obtained using existing coverage prediction methods:

(i) Cells with high unique cell coverage are recognised as such, and may be managed more carefully. For example, a Network Operator may decide to introduce

15   additional equipment redundancy into a particular system to minimise the risk of cell outage.

(ii) Cells with low unique cell coverage can be configured to receive less attention. In some cases, if

20   capacity is not required, it may even be desirable to switch the cell off.

(iii) The aforementioned principles can be extended to encompass the level of unique coverage

25   provided by a group of cells (e.g. a BSC area), or the level of unique coverage provided by a particular sub-layer or frequency band (e.g. a Micro-cell layer, or a cellular 1800 MHz frequency band)

30   (iv) Cells that provide high levels of coverage overlap provide severe constraints on the development of a high quality and capacity frequency plan. Consequently, these cells can be examined to determine

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whether the cell's transmit power can be reduced, the antenna down-tilted, or the cell completely switched off.

Whilst the specific and preferred implementations of the
5   embodiments of the present invention are described above, it is clear that a skilled artisan could readily apply variations and modifications of such inventive concepts.

Thus, a communication system, a communication unit, and a
10   method for coverage prediction have been provided wherein the aforementioned disadvantages associated with prior art arrangements have been substantially alleviated.

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Claims

1.   A method (300) of determining per-cell traffic
coverage in a cellular communication system that
5   comprises multiple cells, the method characterised by the
steps of:

receiving measurements of one or more parameters
relating to one or more operations of a first cell in a
cellular communication system, wherein said one or more
10 parameters includes information relating to whether a
wireless subscriber communication unit can be served by a
number of cells or uniquely served by the first cell; and

calculating (310, 315) a degree of coverage
overlap for said first cell based on a number of said
15 measurements, wherein

said measurements are partitioned (310) into one
or more of at least three categories with respect to the
first cell, wherein:

(i) A first category is where the measurement
20 indicates a wireless subscriber unit that is uniquely
served by the first cell,

(ii) A second category where the measurement
indicates a wireless subscriber unit that can be served
by a number of cells, and

25 (iii) A third category where the measurement
indicates a wireless subscriber unit that is served by a
neighbouring cell but could be served by the first cell.

30 2.   The method (300) of determining per-cell traffic
coverage in a cellular communication system according to
Claim 1, wherein the step of calculating (310, 315) a
degree of coverage overlap based on a number of said

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measurements employs a statistically valid sample of said
measurements.

3.   The method (300) of determining per-cell traffic
5   coverage in a cellular communication system according to
any preceding Claim, wherein the step of calculating
(310, 315) comprises determining an unique coverage
factor (UCF) for that cell, where:

10          $$UCF = \frac{\text{Sum of MRs with no and/or weak neighbours}}{\text{Total Sum of MRs}}$$

4.   The method (300) of determining per-cell traffic
coverage in a cellular communication system according to
15 any preceding Claim, the method further characterised by
the step of:
            converting (315) a number of measurements to
Erlangs to determine a coverage overlap based on
subscriber traffic within said cell.
20

5.   The method (300) of determining per-cell traffic
coverage in a cellular communication system according to
any preceding Claim, the method further characterised by
the step of:
25   allocating a priority, for example an alarm
priority, to said cell based on said calculation.

6.   The method (300) of determining per-cell traffic
coverage in a cellular communication system according to
30 any preceding Claim, the method further characterised by
the step of:
            re-configuring (335) an operational parameter of
said cell, for example a transmit power, a beam-forming

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antenna tilt or direction, or turning off a cell, in
response to said calculation.

7.   The method (300) of determining per-cell traffic
5   coverage in a cellular communication system according to
any preceding Claim, the method further characterised by
the steps of:
        storing said calculations; and
        using (330) said stored calculation subsequently
10 to determine a cell outage strategy.

8.   The method (300) of determining per-cell traffic
coverage in a cellular communication system according to
any preceding Claim, wherein the steps of measuring and
15 calculating are used in an automatic frequency planning
operation of said cellular communication system.

9.   The method (300) of determining per-cell traffic
coverage in a cellular communication system according to
20 any preceding Claim, wherein the wireless communication
unit (146) receives measurement reports from a wireless
serving communication unit, for example a base
transceiver station (122-132), or a wireless subscriber
communication unit (112-116).
25

10.   A storage medium storing processor-implementable
instructions for controlling a processor to carry out the
method steps of any of claims 1 to 9.

30 11.   A communication system (100) adapted to perform
the steps of any of method Claims 1 to 9, the
communication system (100) comprising an overlapping
coverage calculation function (155).

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12.　　A communication unit (146) for use in a cellular communication system that comprises multiple cells, the communication unit (146) comprising:

　　　　a receiving function for receiving measurements
5　of one or more parameters relating to one or more operations of a first cell in said cellular communication system; and

　　　　a processor, operably coupled to said receiving function, to process said received data,
10　the communication unit characterised in that said processor calculates a degree of coverage overlap based on a number of said measurements, wherein:

　　　　said processor partitions said received measurements into at least one of three categories with
15　respect to the first cell, wherein:

　　　　(i) A first category indicates a wireless subscriber unit that is uniquely served by the first cell,

　　　　(ii) A second category where the measurement
20　indicates a wireless subscriber unit that can be served by a number of cells, and

　　　　(iii) A third category where the measurement indicates a wireless subscriber unit that is served by a neighbouring cell but is located such that it could be
25·　served by the first cell.

13.　　The communication unit according to Claim 12, wherein said processor determines an unique coverage factor for a cell (UCF), where:
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$$UCF = \frac{\text{Sum of MRs with no and/or weak neighbours}}{\text{Total Sum of MRs}}$$

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14.   The communication unit according to any of
preceding Claims 12 and 13, wherein said processor
converts a number of measurements to Erlangs to determine
a coverage overlap based on subscriber traffic within
5   said cell.

15.   The communication unit according to Claim 14,
wherein said processor allocates a priority, for example
an alarm priority, to said cell based on said
.10 calculation.

16.   The communication unit according to any of
preceding Claims 12 to 15, wherein said communication
unit or a unit operably coupled to the communication unit
15   re-configures one or more operational parameters of said
cell in response to said calculation.

17.   The communication unit according to Claim 16,
wherein said communication unit configures said cell for
20   transmit power changes, beam-forming antenna changes,
and/or switching off said cell site.

18.   The communication unit according to any of
preceding Claims 12 to 17, wherein said communication
25   unit is an operations and management centre (146)
configured to receive measurement report data relating to
cells in said cellular communication system.

19.   The communication unit according to any of
30   preceding Claims 12 to 18, wherein said measured data
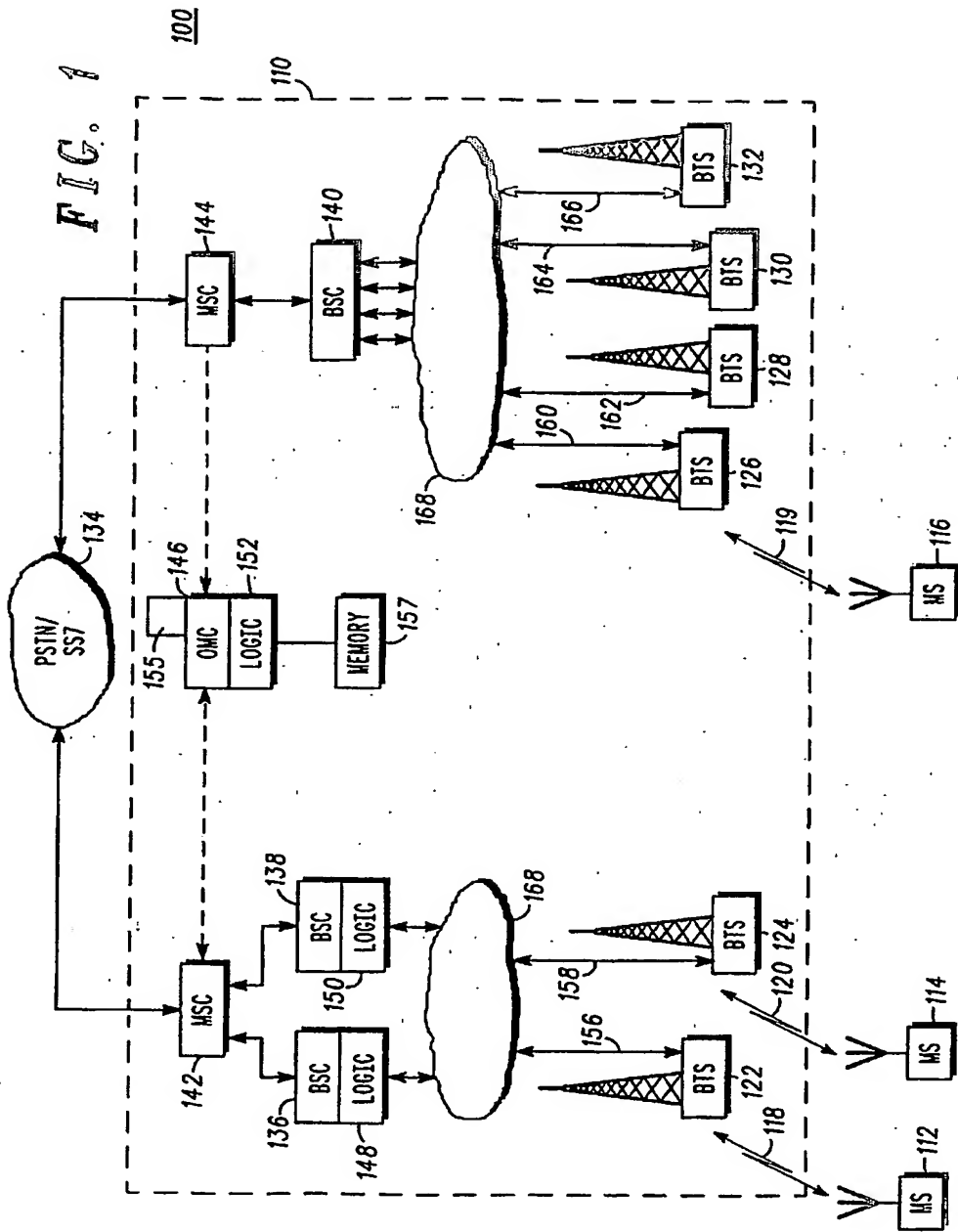includes one or more of the following:

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(i) Cell statistical information, for example in
the form of Congestion, Blocking, Mean-Hold Time (MHT),
Handover (HC) Cause distribution information;

(ii) One or more Measurement Reports; or

5   (iii) Control Signalling behaviour.

20.   The communication unit according to any of
preceding Claims 12 to 19, wherein said processor is
operably coupled to a memory device for storing said
10   calculations for subsequent use in determining a cell
outage strategy.

21.   The communication unit according to any of
preceding Claims 12 to 20, wherein said communication
15   unit is able to communicate on a GSM, GPRS, UMTS, iDEN,
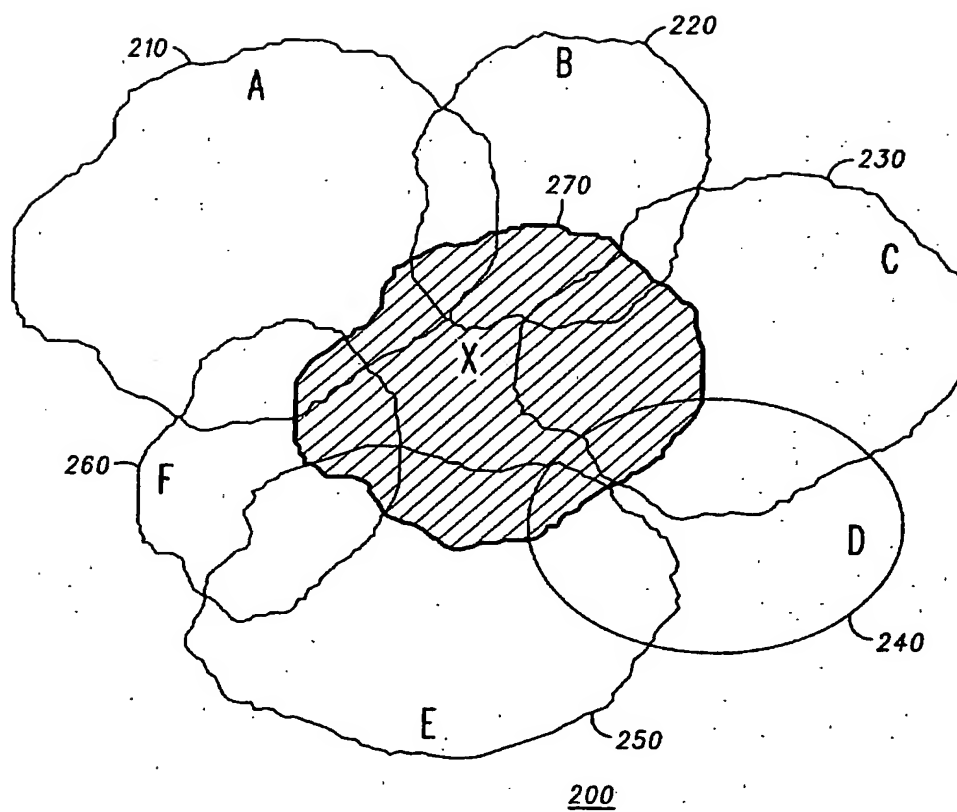or CDMA cellular communication system.

FIG. 1

FIG. 2

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COLLECT MEASUREMENT REPORTS ⌐305

PARTITION MEASUREMENTS INTO: ⌐310
(i) THOES FOR WHICH AN ALTERNATIVE CELL COULD PROVIDE COVERAGE,
(ii) THOSE FOR WHICH THERE IS NO ALTERNATIVE, AND
(iii) THOSE SERVED BY AN ADJACENT CELL THAT COULD BE SERVED BY THE TARGET CELL

CONVERT MEASUREMENTS TO ERLANGS ⌐315

STORE RESULTS AGAINST FOUR HOUR INTERVALS FOR EACH DAY OF THE WEEK ⌐325

USING AS LOOKUP DURING OUTAGE TO DETERMINE IMPACT OF OUTAGE IN TERMS OF PREDICTED ERLANGS AFFECTED AT THAT SPECIFIC TIME OF DAY/DAY OF WEEK ⌐330

SET PRIORITIES FOR PARTICULAR ALARMS 340⌐
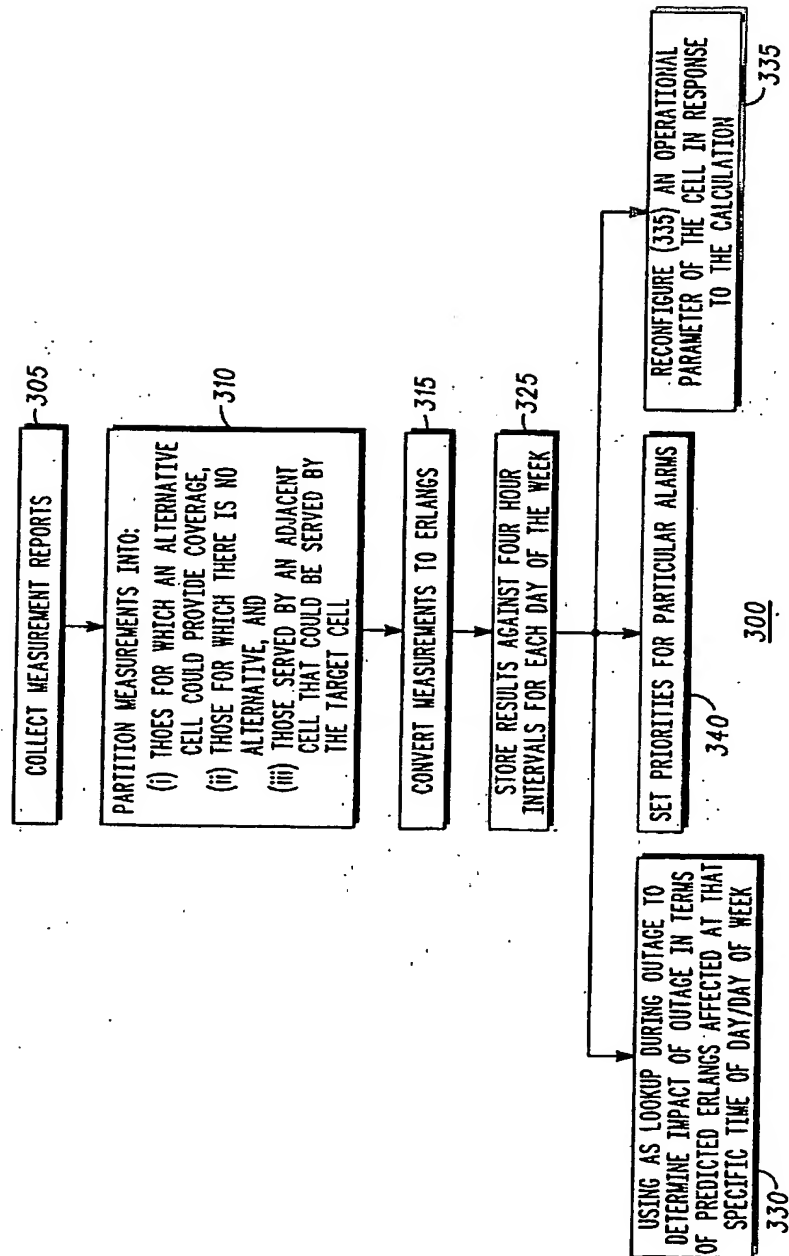
RECONFIGURE (335) AN OPERATIONAL PARAMETER OF THE CELL IN RESPONSE TO THE CALCULATION ⌐335

300

FIG. 3

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